Tobacco Tax

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Professor: School of Economics, UCT
The aim of this presentation

• Introduce some of the most important concepts related to tobacco taxation, and why they are important

• Give an idea of how some of these concepts have been applied

• Hopefully challenge you to apply some of these ideas in your own countries
  – Some ideas are for “formal” academic research
  – Some ideas are aimed at influencing policy
Structure of the presentation

• Important concepts in the tobacco taxation literature
  – Article 6 of the Framework Convention on Tobacco Control
  – Elasticity
  – Excise tax structure
  – Real vs. nominal values
  – Modelling the impact of excise tax increases
  – Tax pass-through
  – Excise taxes and the poor; regressivity
ARTICLE 6 OF THE FCTC
What’s the FCTC?

• Global convention (treaty) on tobacco issues, negotiated between 2000 and 2003, adopted by World Health Assembly in 2003

• Came into force in February 2005, after first 40 ratifications. Very rapid ratification

• At latest report, it has 180 Parties, including most African countries

• It is an evidence-based treaty
What does the FCTC say about tobacco taxes?

Article 6

1. The Parties recognize that price and tax measures are an effective and important means of reducing tobacco consumption by various segments of the population, in particular young persons (emphasis added)

2. Without prejudice to the sovereign right of the Parties to determine and establish their taxation policies, each Party should take account of its national health objectives concerning tobacco control and adopt or maintain, as appropriate, measures which may include: (cont.)
What does the FCTC say about tobacco taxes? (2)

(cont.)

(a) implementing tax policies and, where appropriate, price policies, on tobacco products so as to contribute to the health objectives aimed at reducing tobacco consumption; and

(b) prohibiting or restricting, as appropriate, sales to and/or importations by international travellers of tax- and duty-free tobacco products.
ELASTICITY
Elasticity

• By what percentage does consumption change if the price increases by 1%, ceteris paribus?

• The international experience:
  – International Agency for Research on Cancer (IARC, 2011):
    • High-income countries: between -0.2 and -0.6
    • Low- and middle-income countries: between -0.2 and -0.8

• Implications
  – Increases in the excise tax will decrease consumption but by a lower percentage than the increase in the excise tax
  – An increase in the excise tax will increase tax revenue
What this means in practice

• If the price elasticity is -0.6 and (real) prices increase by 10%, cigarette consumption decreases by 6%.

• How?
  – Reduction in smoking prevalence
    • Reduced initiation
    • Quitting
  – Reduction in smoking intensity
    • Average consumption per smoker decreases
Some techniques in estimating the impact of prices on smoking

• **OLS or derivatives thereof:**
  – Useful for time series
  – Time series data allow one to estimate the overall price elasticity of demand, but not much more

• **Two-step logit/probit with conditional demand**
  – Required: Cross-sectional or panel data
  – Logit/probit to determine the impact of prices on smoking prevalence
  – OLS to determine the impact of prices on the intensity of smoking (the conditional demand) (i.e. how many cigarettes are smoked by remaining smokers)
  – If the data is comprehensive enough, one can analyse the impact of a range of factors on smoking behaviour
More techniques in estimating the impact of prices on smoking

• **Survival analysis techniques**
  – Considers not only *whether* an event takes place, but also *when* the event takes place
  – E.g. smoking initiation and quitting behaviour
  – This requires cross-sectional data
EXCISE TAX STRUCTURE
Excise taxes

• Excise taxes are *discriminatory* taxes levied on specific products, usually to discourage the use thereof

• VAT (and similar sales taxes) is a broad-based indirect tax aimed at raising revenue for government; it is not an excise tax
Excise tax structure

• Three basic structures:
  – Specific (rate per unit)
  – Ad valorem (percentage of value)
  – A combination of specific and ad valorem

• Additional complications:
  – Tiers
    • Different tax rates, based on some physical or economic features, e.g. length of cigarette, type of packaging, filtered or unfiltered, manufactured in factory or cottage industry, locally produced or imported, or price
  – Thresholds
Does tax structure matter a lot?

YES

• From our experience, if a country has a poor excise tax structure, even substantial increases in the excise tax are unlikely to significantly improve public health and/or fiscal outcomes

• Improve the excise tax structure first; then increase the level of the tax
Are uniform specific taxes a good idea?

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to administer – all you need to know is quantity of tobacco products sold/imported/produced; tax bills are easy to calculate.</td>
<td>Does not adjust automatically for inflation – rates must be adjusted regularly to maintain revenues (in real terms).</td>
</tr>
<tr>
<td>Revenues are easy to forecast – only imponderable is industry price reaction. Industry has an incentive to overshift the tax increase.</td>
<td></td>
</tr>
<tr>
<td>Maximum health impact: when (uniform) specific rate is increased, biggest percentage increase comes for cheapest brands.</td>
<td></td>
</tr>
</tbody>
</table>
Are ad valorem taxes a good idea?

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax revenues increase automatically with inflation</td>
<td>Requires tax authorities to know both quantities sold/imported/manufactured and relevant price</td>
</tr>
<tr>
<td>Industry pricing decisions determine level of revenue – and impact on smoking rates</td>
<td></td>
</tr>
<tr>
<td>Revenue impact of increases harder to predict</td>
<td></td>
</tr>
<tr>
<td>Encourages price competition = higher smoking rates</td>
<td></td>
</tr>
</tbody>
</table>
What do the Article 6 Guidelines recommend on ad valorem vs. specific?

“Parties should consider implementing specific or mixed excise systems with a minimum specific tax floor, as these systems have considerable advantages over purely ad valorem systems.”

-- Recommendation at end of Section 3.1

Translated:

• If you already have a specific system, that’s great.
• If you can move to a specific system, that’s also great.
• If you have a purely ad valorem system, at least try to add a specific tax to it.

Source: Francis Thompson, FCA
Two examples of complex tax structures
1. Special consumption tax (SCT):
   - J$128.61 per 100 cigarettes, which was increased to J$ 192 per 100 cigarettes on 14 April 2005;
   - an ad valorem tax of 39.9 % on cigarettes in excess of a benchmark value of J$252.39 per 100 cigarettes. The benchmark value was increased to J$433.81 on 14 April 2005;

2. “Excise levy” payable to the National Health Fund: 23 % of the sum of the ex factory price and the SCT

3. General Consumption Tax (GCT): 15 %, which was increased to 16.5 % on 14 April 2005
## Impact of the tax changes of 14 April 2005

<table>
<thead>
<tr>
<th></th>
<th>Before tax changes</th>
<th>After tax changes</th>
<th>Difference in taxes</th>
<th>Before tax changes</th>
<th>After tax changes</th>
<th>Difference in taxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base price</td>
<td>75.00</td>
<td>75.00</td>
<td>90.00</td>
<td>90.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCT (specific)</td>
<td>25.36</td>
<td>38.40</td>
<td>13.04</td>
<td>25.36</td>
<td>38.40</td>
<td>13.04</td>
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<tr>
<td>SCT (ad valorem)</td>
<td>9.78</td>
<td>0.00</td>
<td>-9.78</td>
<td>15.77</td>
<td>1.29</td>
<td>-14.48</td>
</tr>
<tr>
<td>Subtotal 1</td>
<td>110.14</td>
<td>113.40</td>
<td>-9.78</td>
<td>131.13</td>
<td>129.69</td>
<td></td>
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<tr>
<td>Excise levy</td>
<td>25.33</td>
<td>26.08</td>
<td>0.75</td>
<td>30.16</td>
<td>29.83</td>
<td>-0.33</td>
</tr>
<tr>
<td>Subtotal 2</td>
<td>135.48</td>
<td>139.48</td>
<td>161.29</td>
<td>159.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GCT (@ 15 %)</td>
<td>20.32</td>
<td>20.92</td>
<td>0.60</td>
<td>24.19</td>
<td>23.93</td>
<td>-0.27</td>
</tr>
<tr>
<td>GCT (additional 1.5 %)</td>
<td>2.09</td>
<td>2.09</td>
<td>2.39</td>
<td>2.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tax inclusive retail price</td>
<td>155.80</td>
<td>162.50</td>
<td>185.48</td>
<td>185.84</td>
<td></td>
<td></td>
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<tr>
<td>Change in taxes</td>
<td></td>
<td></td>
<td>6.70</td>
<td></td>
<td></td>
<td>0.36</td>
</tr>
</tbody>
</table>
Bottom line

• The public were told that the SCT was increased by 51%, but the fine print was not reported (or understood)

• The industry increased the “recommended retail price” from J$180 to J$220 per pack, ascribing it to the tax increase

• The fiscal impact of the tax increase was negligible

• The result: Government 1, Industry 7
The cartoonist understood it
Ghana

- Ghana is part of ECOWAS
-Traditionally the excise tax is levied on the CIF (for imports) or ex works (for domestic production) amount
- Officially ECOWAS members may not have excise taxes in excess of 100% of the CIF value
- On cigarettes the excise tax was 150% of CIF amount
- But reported CIF value is only about 7% of the retail price
- Thus excise tax as percentage of retail price is about 11%
Ghana (continued)

• The solution is **not** to increase the ad valorem rate

• *Change the excise tax structure*

• Despite advice from the WHO and the World Bank to change the excise tax structure, the government of Ghana kept the same structure but increased the rate to 175% of CIF value

• Result:
  – No change in the retail price
  – Negligible impact on government revenue
  – This is a massive fail!
Tiers are a particularly bad idea as well

- Tiered taxes reduce the health and revenue benefits of tobacco tax increases
- In a tiered system, increases in tax rates cause some smokers to switch to lower-tier brands, rather than quit (or reduce their consumption)
- If enough smokers do this, it is actually possible to have a decline in revenues
- Manufacturers can often manipulate tiered systems to keep effective taxes low (e.g. move a popular brand into a lower tier)
- Tiered systems are harder to administer and create opportunities for corruption
Some research ideas w.r.t. tax structure

• Historical development of the tax structure in your country

• Limitations (political, economic and “regional”) on changing the excise tax structure

• Political economy of changing the excise tax structure
  – Who has the power to change the structure?
  – What would it require to change the tax structure?

• Modelling the implications of changing the tax structure (see further down)
REAL VS. NOMINAL VALUES
Real vs. nominal values

• The nominal price
  – The price that people actually pay
  – Nominal prices (and values) tend to increase over time as a result of general inflationary effects
  – The public understands nominal prices well
  – The industry prefers talking in nominal prices, because it suits their narrative
Real vs. nominal prices

• The real price
  – This removes the impact of inflation
  – This is the appropriate price when one is comparing prices or values over time
  – Real price$_t$ = Nominal price$_t$/ CPI$_t$
  – Typically the nominal price tends to increase over time; the real price can increase or decrease
Cigarette prices in South Africa

Price per pack of cigarettes

Nominal cigarette price
Real cigarette price (2008 base)
MODELLING THE IMPACT OF TAX INCREASES ON PUBLIC HEALTH AND FISCAL OUTCOMES
Modelling the impact of tax increases

• From a policy perspective, the most common question is: What will be the impact of increasing the excise tax/changing the excise tax?

• This is not hard to do
  – Results follow simple mathematical relationships
  – Some assumptions have a big impact on the results (e.g. price and income elasticity and industry pricing response)
The basic idea

• The retail price can be broken up into tax and non-tax components
  – The government controls the tax components
  – The tobacco industry (and related wholesalers and retailers) control the non-tax components

• Revenues are product of quantity and price component
  – E.g. excise tax revenue = quantity x excise tax per unit
The basic idea (cont.)

• Find appropriate values of quantity, price, price components, revenues in the initial position

• Then “shock” the system
  – Increase the excise tax OR change the excise tax structure
  – Allow the tobacco industry to change the net-of-tax price
  – The joint effect is to change the retail price of cigarettes
  – The change in consumption crucially depends on the price elasticity of demand
  – A change in income can also impact consumption through the income elasticity of demand
The basic idea (cont.)

• Calculate the new simulated consumption
• Based on the new consumption, calculate new revenues
• Calculate percentage changes in the relevant variables
Example

See the Excel model for Jamaica
TAX PASS-THROUGH
Who carries the burden of the tax?

- Standard first-year theory
  - If the government imposes an excise tax, the retail price increases, but by less than the absolute amount of the excise tax increase
  - Price elasticity of demand and price elasticity of supply determines how the excise tax gets shared
  - This analysis assumes a perfectly competitive market
  - Does the analysis change if the firm is a monopolist?
The tobacco industry as a near-monopolist

• What does an industry do when:
  – Its product is being targeted for extra taxes;
  – Consumption of the product is actively discouraged;
  – The industry has significant market power?

• Answer: Milk the consumer
Decomposing the real retail price of cigarettes into tax and non-tax components
The industry has done very well despite the decrease in sales quantity.

[Graph showing trends in cigarette consumption, excise revenue, and industry revenue over time.]
How to do this econometrically

**Static Model:**

\[ \Delta P_{it} = \alpha + B_1 \Delta T_{it} + u_{it} \]

- Difference in real monthly **prices** (for all brands)
- Difference in real monthly **taxes** (for all brands)

**Model with lagged and leading variables:**

\[ \Delta P_{it} = \alpha + \beta_0 \Delta T_{it+1} + \beta_1 \Delta T_{it} + \beta_2 \Delta T_{it-1} + \beta_3 \Delta T_{it-2} + u_{it} \]

- Pre-emptive price response
- Immediate price response
Unfinished research

• Estimate the tax pass-through coefficients for cigarettes for South Africa
  – Initial estimates: between 2 and 3
• With good disaggregated data (used to calculate the CPI) this can be done in other countries as well
• Policy relevance: To determine the likely impact of the excise tax change on the retail price
PREVIOUS PRESENTATION ON TOBACCO EXCISE TAX
Estimating changes in the illicit cigarette market using official data

Corné van Walbeek
School of Economics, UCT

Presentation to the Treasury, 12 September 2013
Some background

• Government have used tobacco excise taxes very effectively to reduce tobacco use in SA

• Since 1994 the *real* tobacco tax has increased by more than 400% (9.7% per annum)
  – Aggregate consumption decreased by a third
  – Smoking prevalence decreased from about 34% in 1993 to about 20% currently
  – Real excise tax revenue increased by 250%
    • Average 8.9% per annum between 1994 and 2003
    • Average 5.5% per annum between 2003 and 2012
  – Nominal excise tax revenue increased more than 10-fold
Cigarette consumption and cigarette prices, 1961 to 2012
Cigarette excise tax revenue and the excise tax per pack, 1961 to 2012

![Graph showing cigarette excise tax revenue and the excise tax per pack, 1961 to 2012.](image)
Industry reaction

• Industry does not like excise tax increases

• Threat of illicit trade
  – Loss of government revenue
  – Unfair to legitimate industry
  – Fuels organised crime and general lawlessness

• Industry estimates of illicit market
  – Between 2006 and 2010 TISA has claimed that 20% of market is illicit
  – 2011: Increased to 26% of total market
  – 2012: Increased to 30% of total market
  – 2013: Indications of 35% of total market (FM article)
The industry’s statistics in more detail

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excise collections (billion cigarettes)</td>
<td>24.4</td>
<td>24.9</td>
<td>25.4</td>
<td>23.9</td>
<td>21.0</td>
<td>20.9</td>
<td>22.2</td>
</tr>
<tr>
<td>Illicit prevalence</td>
<td>21%</td>
<td>11%</td>
<td>8%</td>
<td>10%</td>
<td>21%</td>
<td>26%</td>
<td>30%</td>
</tr>
<tr>
<td>Illicit volume (billion cigarettes)</td>
<td>6.4</td>
<td>3.2</td>
<td>2.1</td>
<td>2.7</td>
<td>5.6</td>
<td>7.5</td>
<td>9.4</td>
</tr>
<tr>
<td>Total consumption (billion cigarettes)</td>
<td>30.8</td>
<td>28.1</td>
<td>27.5</td>
<td>26.6</td>
<td>26.6</td>
<td>28.4</td>
<td>31.6</td>
</tr>
<tr>
<td>Percentage increase in total consumption</td>
<td>-8.8%</td>
<td>-2.1%</td>
<td>-3.3%</td>
<td>0.0%</td>
<td>6.8%</td>
<td>11.3%</td>
<td></td>
</tr>
</tbody>
</table>

**Source:**
First three rows directly from TISA presentation May 2013
Last two rows derived from rows above
Some observations

• Significant decrease in industry’s estimates of illicit trade in 2007 and 2008
  – Not a single newspaper article in those years suggested that illicit trade was decreasing
  – TISA continued with its claim that 20% of the market was illicit

• Our analysis broadly agrees with TISA’s finding of a spike in illicit trade in 2010

• The claimed increase in illicit trade in 2011 and 2012 implies that total (legal plus illicit) cigarette consumption in those years increased by 6.8% and 11.3% respectively
  – This is highly unusual in a country with modest economic growth, a fairly strong anti-smoking environment and decreasing smoking prevalence
Some observations (continued)

• Despite a pretty impressive methodology, the results of the industry’s estimates of the size of the illicit market are simply not credible
  – Especially 2011 and 2012

• The tobacco industry uses the survey results in an asymmetric way:
  – “Increases” in illicit trade get attention
  – “Decreases” in illicit trade are ignored
An alternative approach to measuring changes in the illicit market

• Theoretically and empirically we know that there is a very strong relationship between cigarette consumption (the dependent variable) and cigarette prices and income (independent variables)

• Time series studies (using 1970 to 1990s annual data) by Reekie (1994), Van Walbeek (1996, 2005), Van der Merwe and Annett (1998) and ETCSA (2003) suggest *price elasticity of about* -0.6 and *income elasticity of 0.6*

• Very high $R^2$ values (0.9 or greater) suggest that these two independent variables explain nearly all variation in cigarette consumption over time
Simulation analysis

• By how much would we expect total consumption to change, given changes in the demand determinants?
• Price is the weighted average of actual prices as surveyed by Stats SA
  – This is lower than the recommended retail price of MPPC cigarettes
• Compare change in legal consumption with predicted change in total consumption
• If legal consumption drops by more than predicted by model, this suggests increase in illicit market
• If legal consumption drops by less (or increases by more) than predicted by the model, this suggests a decrease in the illicit market
# Cigarette prices used in the simulation exercise

<table>
<thead>
<tr>
<th>Year</th>
<th>Stats SA implied average price (nominal)</th>
<th>MPPC average price (nominal)</th>
<th>Peter Stuyvesant average price (nominal)</th>
<th>“Discount” of average vs. MPPC price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>R9.74</td>
<td>R10.23</td>
<td>R10.18</td>
<td>4.8%</td>
</tr>
<tr>
<td>2003</td>
<td>R10.67</td>
<td>R11.60</td>
<td>R11.51</td>
<td>8.0%</td>
</tr>
<tr>
<td>2004</td>
<td>R11.12</td>
<td>R12.88</td>
<td>R12.82</td>
<td>13.7%</td>
</tr>
<tr>
<td>2005</td>
<td>R12.53</td>
<td>R14.05</td>
<td>R13.97</td>
<td>10.8%</td>
</tr>
<tr>
<td>2006</td>
<td>R13.51</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2007</td>
<td>R14.91</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2008</td>
<td>R16.27</td>
<td>R19.17</td>
<td>R19.17</td>
<td>15.1%</td>
</tr>
<tr>
<td>2009</td>
<td>R18.60</td>
<td>R22.29</td>
<td>R22.26</td>
<td>16.6%</td>
</tr>
<tr>
<td>2010</td>
<td>R20.96</td>
<td>R24.98</td>
<td>R24.83</td>
<td>16.1%</td>
</tr>
<tr>
<td>2011</td>
<td>R22.15</td>
<td>R26.53</td>
<td>R26.45</td>
<td>16.5%</td>
</tr>
<tr>
<td>2012</td>
<td>R23.24</td>
<td>R27.78</td>
<td>R27.77</td>
<td>16.3%</td>
</tr>
</tbody>
</table>
Example

- In 2005/06 real price increased by 5.7% and real GDP increased by 5.2%

- Predicted increase in cigarette consumption:
  \[= (-0.6 \times 5.7) + (0.6 \times 5.2) = -0.3\%\]

- Actual cigarette consumption increased by 1.0%

- Thus illicit market decreased by 1.3 percentage points
<table>
<thead>
<tr>
<th>Financial year</th>
<th>Percentage change in quantity</th>
<th>Percentage change</th>
<th>Simulation: Percentage changes</th>
<th>“Size of the illicit market”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Budgeted</td>
<td>Actual</td>
<td>Real price</td>
<td>Real GDP</td>
</tr>
<tr>
<td>1999/2000</td>
<td>-4.0</td>
<td>-6.7</td>
<td>14.1</td>
<td>3.0</td>
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<td>2000/2001</td>
<td>-5.2</td>
<td>-4.9</td>
<td>5.4</td>
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<tr>
<td>2001/2002</td>
<td>-5.9</td>
<td>-3.1</td>
<td>4.7</td>
<td>2.7</td>
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<td>2002/2003</td>
<td>-5.5</td>
<td>-3.7</td>
<td>0.5</td>
<td>3.6</td>
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<td>2003/2004</td>
<td>-1.2</td>
<td>0.7</td>
<td>7.8</td>
<td>3.1</td>
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<td>2004/2005</td>
<td>-6.0</td>
<td>-2.3</td>
<td>6.7</td>
<td>5.0</td>
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<td>2005/2006</td>
<td>-1.1</td>
<td>1.0</td>
<td>5.7</td>
<td>5.2</td>
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<td>2006/2007</td>
<td>4.7</td>
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<td>2.7</td>
<td>6.0</td>
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<td>2007/2008</td>
<td>-0.4</td>
<td>2.1</td>
<td>2.2</td>
<td>4.8</td>
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<td>2008/2009</td>
<td>-1.4</td>
<td>2.0</td>
<td>-1.5</td>
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<td>2009/2010</td>
<td>-1.7</td>
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<td>2010/2011</td>
<td>-0.8</td>
<td>-12.2</td>
<td>6.7</td>
<td>3.4</td>
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<tr>
<td>2011/2012</td>
<td>3.9</td>
<td>-0.3</td>
<td>-0.4</td>
<td>3.1</td>
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<td>2012/2013</td>
<td>8.9</td>
<td>6.3</td>
<td>-0.6</td>
<td>2.7</td>
</tr>
</tbody>
</table>
What this analysis indicates

• The analysis is better at indicating approximate changes in the illicit market share than at giving a precise estimate of the size of the illicit market at any point in time

• As such it is better at showing trends in the illicit market

• The analysis only considers changes in cigarette prices and income; the impact of legislative changes (e.g. in 2001) is not included
  – One would expect the advertising ban and smoke-free policies to have reduced total consumption in 2001 and subsequently
  – To the extent that these legislative interventions impact cigarette use, the current figures overstate the illicit market
Conclusion

- Illicit trade in cigarettes is a real problem, and deserves focused attention
- Due to the nature of the activity, it is hard to measure accurately
- Estimates by industry and survey companies have significant flaws:
  - They often do not make logical sense
  - They restate history without proper explanation
  - The results are used asymmetrically
  - They presumably are self-serving, to divert attention from further excise tax increases
Conclusion (continued)

• What should Treasury do?
  – Focus on good quality data, rather than on industry-provided data and anecdotes
  – The best data is excise tax revenue data
  – “Are we receiving the revenue that we would expect to receive, given what we know of the determinants of cigarette demand?”
Additional slides
Budgeted and actual cigarette tax revenue: a long term analysis

Corné van Walbeek
Deviations from budgeted revenue for three products

Percentage deviation from budgeted revenue

Beer
Spirits
Cigarettes and tobacco

Compare differences between actual and budgeted tax revenue for three similar products

- Statistics to compare deviations from budget over multiple periods:
  
  (1) \[ MPE = \frac{1}{n} \sum_{i=1}^{n} \left[ \frac{(A_i - B_i)}{B_i} \times 100 \right] \]
  
  (2) \[ RMSPE = \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left[ \frac{(A_i - B_i)}{B_i} \times 100 \right]^2} \]

  \( A_i = \) actual tax revenue;
  
  \( B_i = \) budgeted tax revenue;
  
  \( n = \) number of years
## Mean percentage error (MPE)

<table>
<thead>
<tr>
<th>Period</th>
<th>Number of years</th>
<th>Beer</th>
<th>Spirits</th>
<th>Cigarettes</th>
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<tbody>
<tr>
<td>1910/11 to 1944/45 (pre-WW2)</td>
<td>35</td>
<td>5.0</td>
<td>2.7</td>
<td>6.4</td>
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<tr>
<td>1945/46 to 2012/13 (post-WW2)</td>
<td>68</td>
<td>1.7</td>
<td>-1.4</td>
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</tr>
<tr>
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<td>-1.3</td>
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<td>-0.1</td>
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<td>5.4</td>
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<td>1970/71 to 1979/80</td>
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<td><strong>-3.1</strong></td>
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<tr>
<td><strong>2005/06 to 2012/13</strong></td>
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### Root mean square percentage error (RMSPE)

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